Synopsis

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Title:- Groundwater Modeling for Sustainable Management of Water Resources in Drought Prone Area - A Case Study of Micro watersheds 4E3B3k4 and 4E3C2j2.

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Groundwater Modeling for Sustainable Management of Water Resources in Drought Prone Area - A Case Study of Micro watersheds 4E3B3k4 and 4E3C2j2.

Introduction

India is the second most populous country in the world, with a population exceeding 1.3 billion and it is predicated that it will cross Chain by 2040. India has an agriculture-based economy. It has 2.45 % of the total land area of the world, catering 16% of the world population and is estimated to be endowed with about 4% of its water resources. Annual average rainfall in the country is 1170 mm, which corresponds to annual precipitation, including snowfall of about 4000 billion cubic meters (bcm). Out of this, about 1869 bcm is estimated as the average annual potential flow in rivers. On account of various constraints, only 1122 bcm of water is assessed as the annual utilizable water, having surface water resources component of 690 bcm and ground water component of 433bcm.

Rapid expansion in the use of ground water, primarily for irrigation, has contributed significantly to its agricultural and economic development. The irrigation potential created from ground water has increased from 6.50 Million hectares (m.ha.) in 1950 to about 70 m.ha. at present. The net area irrigated by different sources in the country has increased from 22.80 m ha during 1955-56 to about 66.20 m ha (provisional) during 2016-17. A comparative study of the percent area irrigated by surface water sources (including Canals, tanks and other sources) and the ground water sources (tube wells and other wells) indicates that ground water has been the major source of irrigation in the country since 1970s. Average area irrigated from surface water sources has decreased from about 70 percent during1955-65 to about 40 percent in 1996-2005, whereas area underground water irrigation has registered an increase from 30 percent to about 60 percent during the period. Hence, it is seen that ground water has been the major source of irrigation in India from 1976-77 onwards.

Specialized form of water balance equation that requires quantification of the components of inflow to and outflow from a groundwater reservoir, as well as changes in storage therein. Some of these are directly measurable, few may be determined by differences between measured volumes or rates of flow of surface water, and some require indirect methods of estimation.

Literature Review

In this section the survey and review of literature is presented. One of the most important advances made in the field of water resources engineering during the last two decades is the evolvement and application of optimization techniques for planning, design and operation of complex water resources system.

Minor et al., (1994) studied about to present a unique methodology on groundwater for exploration using the technique of remote sensing and GIS, particularly in developing countries. They developed interpretation strategies that integrate various data types to characterize groundwater resources for locating a well point. Field observations and several remote sensing platforms are essential to create GIS based hydrogeological model on any study area.

Krishnamurthy et al., (1996) studied GIS based model for distinguishing groundwater potential zones of Marudaiyar bowl, Tamil Nadu, India by joining distinctive topical layers, for instance, lithology, landforms, lineaments and surface water body on 1:50,000 scale were used as a piece of their work, what's more waste thickness and slant guide was utilized from toposheets. Furthermore a soil guide of 1:50,000 scale was made from soil toposheets and range used cooperation by regrouping the centered around their hydrological angles. All the topical layers were composed and analyzed using GIS model to achieve groundwater potential guide. They had concluded that accumulated from field were acknowledged by the usage of field data. The approach graph was profited and may be viably used as a piece of other equivalent catchments with suitable modifications.

Shanta, kumar et al., (1996) investigated that remote sensing and GIS technique for delineating potential areas for groundwater recharge for the entire state of Tamil Nadu. Thematic maps of geomorphology, geology, soil, slope, land use, drainage density, lineament density, runoff and depth of water table zones were taken into consideration.

SujathaBiswar et al., (1999) investigated Use of satellite data to identify various geomorphic features of the upper Baitarani river basin of Orissa. Finally they concluded that the land features

into denudation and fluvial origin and evaluated the groundwater potential of various landforms of the study area.

Kumar et al.,(2000), studied about the assessment of groundwater. The general methodology of computing groundwater balance consists of Identification of significant components, Evaluating and quantifying individual components, and Presentation in the form of water balance equation. It also provides knowledge about the purposes that groundwater balance study of an area serve, ground water balance equation and ground water resources estimation methodologies. They had concluded that Groundwater exploitation should be such that protection from depletion is provided, protection from pollution is provided, negative ecological effects are reduced to a minimum and economic efficiency of exploitation is attained.

Seenivasan K.M. et al.,(2000) studied about Delineating groundwater potential zones using remote sensing and GIS. They had concluded that getting Suitable sites for the construction of artificial recharge structures and Targeting of groundwater (to pin point the exact location, detailed electrical resistivity survey has to be conducted)

Mozzammel et al., (2005), formulated a plan for conjunctive use of surface water and ground water for the area facing the problem of shortage of surface water. A improved cropping pattern is developed for kharif and rabi season and predicted the groundwater availability to meet the required irrigation water demand by applying a numerical method. They had concluded that the groundwater use has environmental impact in the area in terms of effects on the shallow or drinking water.

Sangole Shivshankar, et al.,(2005) studied that water resources have been affected in such a way that they are not available for further use without prior treatment. Contamination of surface water may disappear within a short period of time, once the discharge source is controlled, but for groundwater, contamination may persist for many years and depuration strategies would require substantial research and financial efforts. They concluded that Rainwater harvesting is one of the solution to minimize the fluoride concentration in drinking water. Hydrological study of shallow and deep aquifers should be done in order to understand intensity of pollution and sources of pollutants.

Mane M.S. et al. (2010) investigated the optimal crop planning and conjunctive water use planning. This research formulates a linear programming model and a solver computer program for the left Dadupur and its associated distributaries and minors in Bulandshahar district of Utter Pradesh. To maximize the net benefit conjunctive water use planning optimization is done season wise. They had concluded that conjunctive water use planning using optimization approach the net benefits could be raised and generating the employment potential.

Deepesh Machiwal et al., (2010) proposed a standard methodology to delineate groundwater potential zones using integrated RS, GIS and multi-criteria decision making (MCDM) techniques. The methodology is demonstrated by a case study in Udaipur district of Rajasthan, western India. Initially, ten thematic layers have been considered. Weights of the thematic layers and their features then normalized by using AHP (analytic hierarchy process) MCDM technique and eigenvector method. Finally, the selected thematic maps were integrated by weighted linear combination method in a GIS environment to generate a groundwater potential map.

Jenifa Latha.C et al., (2010) investigated that sufficient water is not available during the dry season. The water sector is very sensitive and is strongly influenced by the changes in climate and land use. Hence, it has the potential to impose additional pressures on water availability, water accessibility and water demand in the Amaravathi river basin. They had concluded that July to October was found to be surplus months in most of the years. The results are useful in agricultural planning, recharge by rain water harvesting, ground water modeling, vulnerability studies, etc. in the area.

Nag.S.K et al., (2011) studied about to identify the groundwater potential zones in the Dwarakeswar Watershed based on remote sensing and GIS techniques. They had concluded that In general slope greater than 30^0 there by indicating more runoff and less infiltration. The central and southern part of the watershed areas provides good prospect for groundwater.

Khadri S.F.R et al.,(2013), investigated about use of remote sensing and GIS technique in groundwater recharge investigations. The general methodology Open Source satellite image was used for linear, aerial for drainage basin analysis and interpretation, the maps were geo-referenced and digitized using the Arc GIS 10 and attributes were assigned to create the digital

database. This research formulate proposed study will certainly fill the crucial gap of knowledge related to the salinity problem by providing detailed field and laboratory data with GIS analysis for proper interpretation. They had concluded that a Role of remote sensing and GIS based methodology has been developed and demonstrated for evaluation of groundwater resources.

Mallikarjuna V. et al., (2013) investigated that Water budget is a basic tool that can be used to evaluate the occurrence and movement of water through the natural environment. The water budget model is usually set up on a monthly basis to calculate monthly independent results rather than month to month continuous water balance. Form study it is concluded that with the diversion of 80 TMC of Godavari waters to Krishna, on an average the variation of water balance is about 18.45 cm, decreasing the deficiency of water to some extent which is worthy to the population of Delta region.

Waikar M.L. et al.,(2014) studied about the Identification of groundwater occurrence location using remote sensing data is based on indirect analysis of directly observable terrain features like geological structures, geomorphology, and their hydrologic characteristics, they had concluded that Geographical information system and remote sensing has proved to be powerful and cost effective method for determining groundwater potential in parts of Parbhani district. The study reveals that integration of six thematic maps such as drainage density, slope, geology, geomorphology, lineament density and land use/land cover gives first-hand information to local authorities and planners about the areas suitable for groundwater exploration.

Subramani T. et al., (2014) investigated about land use mapping, comprehensive database for resources and analytical tools for decision making and impact analysis for plan evaluation. They had concluded that the areas potential for the occurrence of groundwater, by using different thematic layers pertaining to geomorphology, and land use / Land cover, Lithology, Slope were assigned with weight age values according to their favor less for groundwater and integrated in GIS environment and classified into very low, low, moderate, high and very high groundwater potential zones.

Surajit Murasingh et al., (2014) studied to estimate the groundwater potential and scarcity in Tensa valley and a sub-basin of Brahmani river basin (samij sub-basin) of Odisha, India.

Integration of different above techniques to developed groundwater potential map. They had concluded that the coastal regions of Odisha state are found to be utilizing groundwater more than interior districts of the State, The integration of all the thematic maps result six groundwater potential zones – poor, moderate, good, very good and excellent –and the weighted range for various groundwater potential zones were categorized.

Ramamoorthy. P et al., (2015) investigated about Groundwater is a significant natural resource in present day, but of limited use due to frequent failures in monsoon, undependable surface water, and rapid urbanization and industrialization have created a major risk to this valuable resource. They had concluded that clear that good and moderate sources of groundwater potential zones are confined to the Southwest and North east part of the study area. The Potential zone map could be used for various purposes like irrigation, drinking and management of groundwater etc.

M.S.Mane et al. (2016) investigated about Conjunctive water use planning using optimization approach helps us to study the optimal crop planning and conjunctive water use planning. This research formulates a linear programming model and a solver computer program for the left Dadupur and its associated distributaries and minors in Bulandshahar district of Utter Pradesh. Result indicated that conjunctive water use planning using optimization approach the net benefits could be raised and generating the employment potential of 3.69 million persons hrs.

Younes Noorollahi (2016) investigated about application of GIS and remote sensing in exploration and environmental management of geothermal area ice-land. They concluded that GIS-based decision making offers a way to engineers and scientists to decide on each factor individually instead of going through a very complex decision making process using the traditional analog method and also reduces the possibility of human errors in the decision making process.

Brian A. Smith et al (2018) studied about being conducted to better understand the horizontal and vertical flow components of the Trinity Aquifers. These studies involve aquifer testing, groundwater geochemistry, geologic and structural mapping, flow-loss/gain measurements in streams, hydraulic head measurements, dye tracing, and installation of multiport monitor wells.

The implications of this study will influence future hydro-geologic evaluations and modeling. Evaluations include the potential for impacts to existing domestic-supply wells by large-scale pumping of wells completed in the Balcones Fault Zone Middle Trinity Aquifer.

P. Arulbalaji et al (2019) studied total of 12 thematic layers in small humid tropical river basin in South India - the Vamanapuram river basin, such as Geology, Geomorphology, Land Use/Land Cover, Lineament density, Drainage density, Rainfall, Soil, Slope, Roughness, Topographic Wetness Index, Topographic Position Index and Curvature were prepared and studied for groundwater potential zone demarcation. Weights assigned to each class in all the thematic maps are based on their characteristics and water potential capacity through AHP method. The study reveals that about 59% of the river basin is covered under moderate groundwater potential zone. The low and high groundwater potential zones are observed in 29% and 11% respectively. Areas under very high and very low potential zones are recorded only in very limited areas in the basin.

Charles D.D. Howard (2002) has identified that Water management sustainability is depends upon three factors Water supply probability at shortage, The cost when shortages are encountered in the level of acceptability of risks and sustainable system that maintains acceptable risks over and indefinite time horizon. Water resources sustainability should be considered between structures of probability. Risk is a cost measured in units of ecosystem productivity, money, public health incidents or any other measure of failure or success.

N. Sundararajan (2019) has solved the problem of Hyderabad which is linked with surface water (lakes) namely RK Puramcheruvu, Nadimicheruvu, Bandacheruvu, Patelcheruvu, Peddacheruvu and Nallacheruvu. The purpose of this entire study is to calculate capacity of the storage treatment plants (STP) and to find out seepage to groundwater for water budget. They used Modflow software for ground water modelling. The groundwater withdrawal was estimated based on the well inventory, average running hour of pumps and residential distribution in the area. This research shows that by model calculation groundwater velocity estimation was 0.26 m/day. Considering lake seepage and evaporation loss capacity of STP of various lakes estimated and from TDS and groundwater velocity load in lakes they projected present and next 20 years contamination.

C. P. Kumar (2015) has given details about data and software required for solving groundwater modelling problem. For groundwater modelling basic three models are required physical model, mathematical model and numerical model. To solve ground water modelling problem eight steps are to be followed, by following these steps ground water modelling can be done easily. All required data is classified into two groups Physical framework and Hydrological stress with help of Physical framework different maps are drawn Geological, Topographical, Land use, contour and Isopach maps. By Hydrological stress data we collect information of Water table and potentiometric maps, groundwater head surface water levels and discharge rates, hydraulic conductivity, storage properties of the aquifers, in additional water table elevations, geophysical data, seismic, records of pumping abstraction, recharge and evapotranspiration these data are required for modelling. For accurate estimation from model calibration is essential tool.

Sushant Kumar and M. K. Choudhary (2017) The study focused on Groundwater assessment of Bina River tributary of Betwa River with Software Modflow. Upper part of Study area is The upper part of the study area is undulating, mostly gentle sloping and covered by forests. Data required for Groundwater assessment is Evapotranspiration which is calculated from actual PET, Rainfall, pumping well, pumping test, Groundwater Level Analysis, Geophysics data taken by CGWB and WRD. Property zones like specific yield, specific storages, and initial head are carried out on based on geographic information of study area. Using Modflow software a Finite difference grid of 100 x 80 numbers of Rows and columns are taken into consideration. height and width value of 622.5 and 1044.8 m. final conclusion is study area having low Groundwater rate so pumping rate should be low otherwise groundwater level becomes low than definite level.
Namitha MR (2019) the study carried out in Nileshwar river basin of Kasargod district, which is a drought prone district of northern Kerala. They used Visual MODFLOW 2.8.1. Software for a three-dimensional finite difference modelling program for research and estimate aquifer system in study area. Used data was Digital elevation model which will cover complete study area, basic meteorological data, Hydrogeologic and geologic characteristics and parameters and Well data. After running model they founded that main reason of increasing Groundwater table is Rainfall, because study area has undulating topography, finally they concluded as inaccurate model can results if presentation of data is incorrect and designed model can be used for further studies.

S. Deepa S. (2016) this study focused on factor which control movement and occurrence of Groundwater in hard rock which is in Upper Manimuktha sub basin, Velar river, Tamil Nadu. Study area falls in agricultural zone in which main crops are sugarcane, paddy, and groundnut are being cultivated. They prepared base map of study area using Arc GIS 9.3 software, after base map collected data from satellite imageries and some other collateral to prepare thematic layers like geology, geomorphology, present slope, drainage density, lineament density and land use/land cover of the study area. They concluded that the lineament of study area is obstructing water from groundwater recharge only 34.4% of rainwater is infiltrate in the ground of study area, for this extra sustainable developments required to recharge maximum groundwater.

S. F. R. Khadri (2016) They developed mathematical groundwater model for the Mahesh River basin in the Akola and Buldhana districts , it was calibrated with observed vs historical water level data for the year of 2013 to 2014. Data collected for modelling are hydrological, hydrogeological, rainfall and well data. They concluded that model gives more accurate results when collected data and input parameters are proper. To minimize modelling errors hydrogeological judgment should be appropriate. This model is useful for identification of groundwater levels variation under different hypothesis conditions in Mahesh River basin by using this model balanced groundwater management is to be done.

Navdeep Kaur (2019) has solved groundwater sustainability problem of Sirhind Canal Tract (SCT) of Punjab by using Modflow software, they calibrated model for various aquifer parameter like specific yield, hydraulic conductivity and boundary conditions for observed groundwater data for the year 1998-2012(15 years) and validated for 2013-2017 (5 years), After running model results indicated that current groundwater pattern is slightly matched with previous groundwater pattern. Main reason of difference between observed and current groundwater level was increase in independency of tube well if new tube wells are not taken in consideration of modelling then in next 12 years groundwater will fall by 20 m. To maintain groundwater level canal networks were repaired and leakages minimised, by doing repair and maintains work availability of canal water increased by 10% in each block and this water used for domestic and agricultural purpose, so that use of Tube wells reduced up to certain limit and groundwater level also maintained properly.

J.S. Rawat and Manish Kumar (2015) the study conducted in new developed part of Almora district in Uttarakhand state.in this study they prepared Land use/ Land cover maps for 20 years from 1990 to 2010 by using Global Land Cover Facility Site (GLCF) and earth explorer site by dividing study area into four categories. First category is vegetation and it increases by 3.51% in study area because of afforestation during last 20 years, second category is agriculture it reduced by 1.52% due to vegetation and new constructions. Third category is unfertile land it decreased by 5.46% due to vegetation, built-up land and conversion in agriculture. Fourth category is built up area which increases by 3.55%. With the use of remote sensing and GIS it is possible to do time based study and quantification of spatial phenomena, with more precisely and with low cost we can easily discover changes happened in any area.

Namitha MR(2019) They developed model for Nileshwar river of northern Kerala. Model was developed to discover characteristics of groundwater by ground water modelling using MODFLOW 2.8.1. They prepared Digital Elevation Model by using topographical map,The basic meteorological data, Hydrogeologic and geologic characteristics and parameters and Well data. Rainfall is the main sources of Groundwater recharge because it is having undulating topography and a bad representation of data can give inaccurate model.these output are helpful for further studies.

Sujata Biswas(2020) In this study with the help of LISS III and MODIS sensors agricultural drought was analysed in Puruliya district of West Bengal. Study area faces drought condition in the months of March and April for 2000, 2002, 2010 and 2011 excluding the forest area with the help of LISS III NDVI and by MODIS sensor indicates major portion of study area is under drought conditions for 2002, 2010 and 2011 they compared this study for 2015-16 they concluded that 76.5% area having rabi crop and 34.1% having Kharif crop it is suffering from saviour drought condition and around 70% 0f area is under drought condition.

Biswajit Das and Subodh Chandra Pal (2018) They used Remote sensing and geographical information system (RS-GIS) for mapping and modeling of groundwater resources of Puruliya district West Bengal. With the help of software they prepared required thematic maps like geology, slope, lineament density, land use land cover, soil, rainfall and groundwater fluctuation to find out potential zones of the study area. They classified total area into three groundwater

potential zones high, moderate, and low. Around 60.92% of the total study area comes under the moderate potentiality zone, about 22.55% area falls under high potential zone and 16.53% of the total area under low potential zone, respectively. Around 71.43% of validation points matches with expected yield classes so they concluded that this study help to give better cropping pattern for the study area.

The Title of the PhD. Thesis

The approved title of this thesis is viz. **"Groundwater Modeling for Sustainable Management of Water Resources in Drought Prone Area - A Case Study of Micro watersheds 4E3B3k4 and 4E3C2j2."**

The Scope and coverage of the Research Studies

The scope and coverage of this study broadly consists of following aspects.

Various development activities over the years have adversely affected the ground water regime in many parts of the country. There is a need for scientific planning in development of ground water under different hydrogeological situations and to evolve effective management practices with involvement of community for better ground water governance. Though a vast amount of hydrological and hydrogeological data have been generated through scientific investigations by Central Ground Water Board and other Central/State agencies, these mostly pertain to administrative units and have addressed the issues of the whole aquifer systems in very few cases. In view of the emerging challenges in the ground water sector in the country, there is an urgent need for comprehensive and realistic information pertaining to various aspects of ground water resources available in different hydro-geological settings through a process of systematic data collection, compilation, data generation, analysis and synthesis.

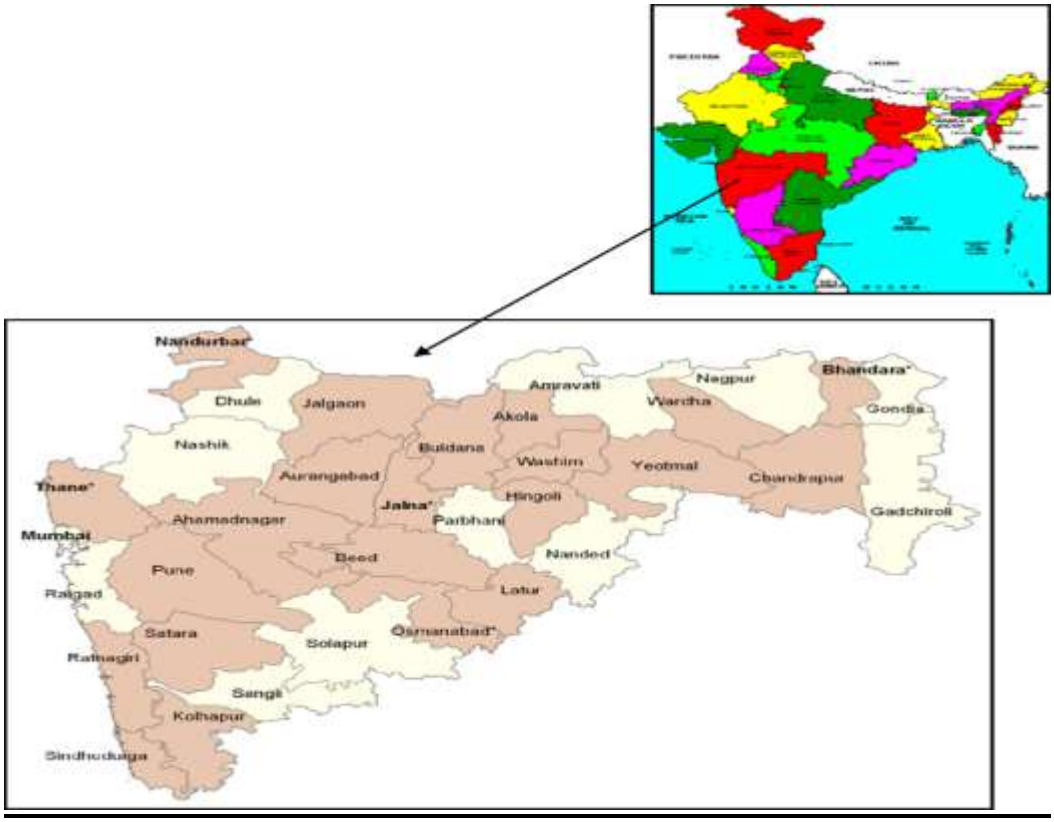
Objectives of Study

1. To simulate the groundwater flow in the study area to understand the groundwater level fluctuations and assess quantity to meet the water demand of a city.
2. To predict the reaction of an aquifer to different environmental stress scenarios in the study area
3. To prepare a pictorial representation of the geohydrological profile of the study area to represent the soil layers in the study area with Visual MODFLOW.
4. To use modelling to assess the safe yield of groundwater withdrawal and quantify the future demand of water supply for the Nanded city.

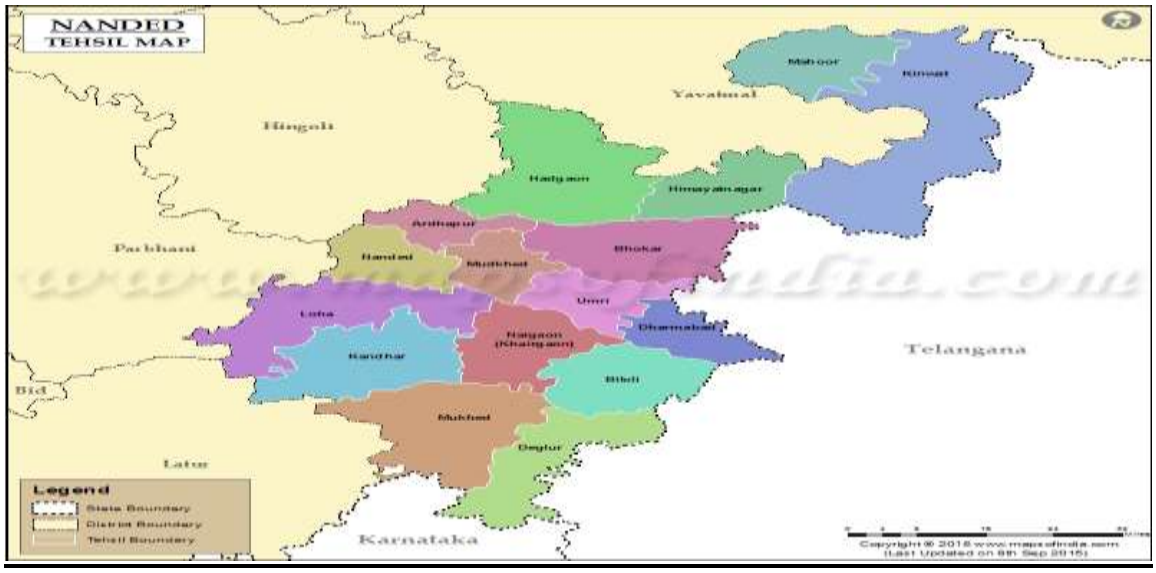
Methodology

- Collection of data of study area eg. Rainfall, surface water, Groundwater data, soil, Agricultural, Climatic data and population of study area
- Geological and Geophysical survey of the study area
- Preparation of maps like Topographical, Geological and Geomorphological in the study area
- Groundwater Modeling of the study area
- Propose water budget for study area

Study Area



Map of Maharashtra

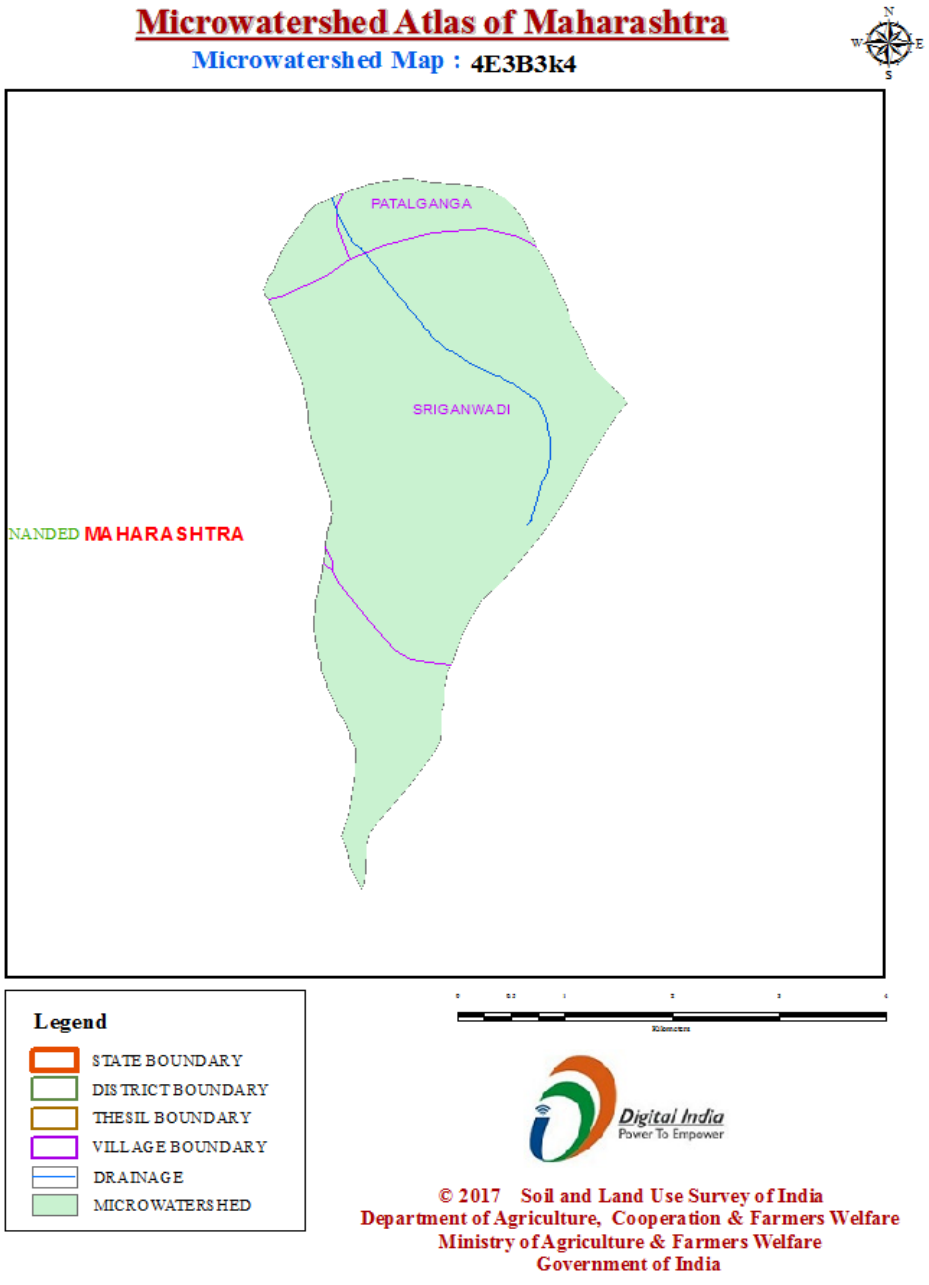


Nanded Tehsil map

Micro watershed number:-4E3B3k4

Total area:-1110.56 Sqm

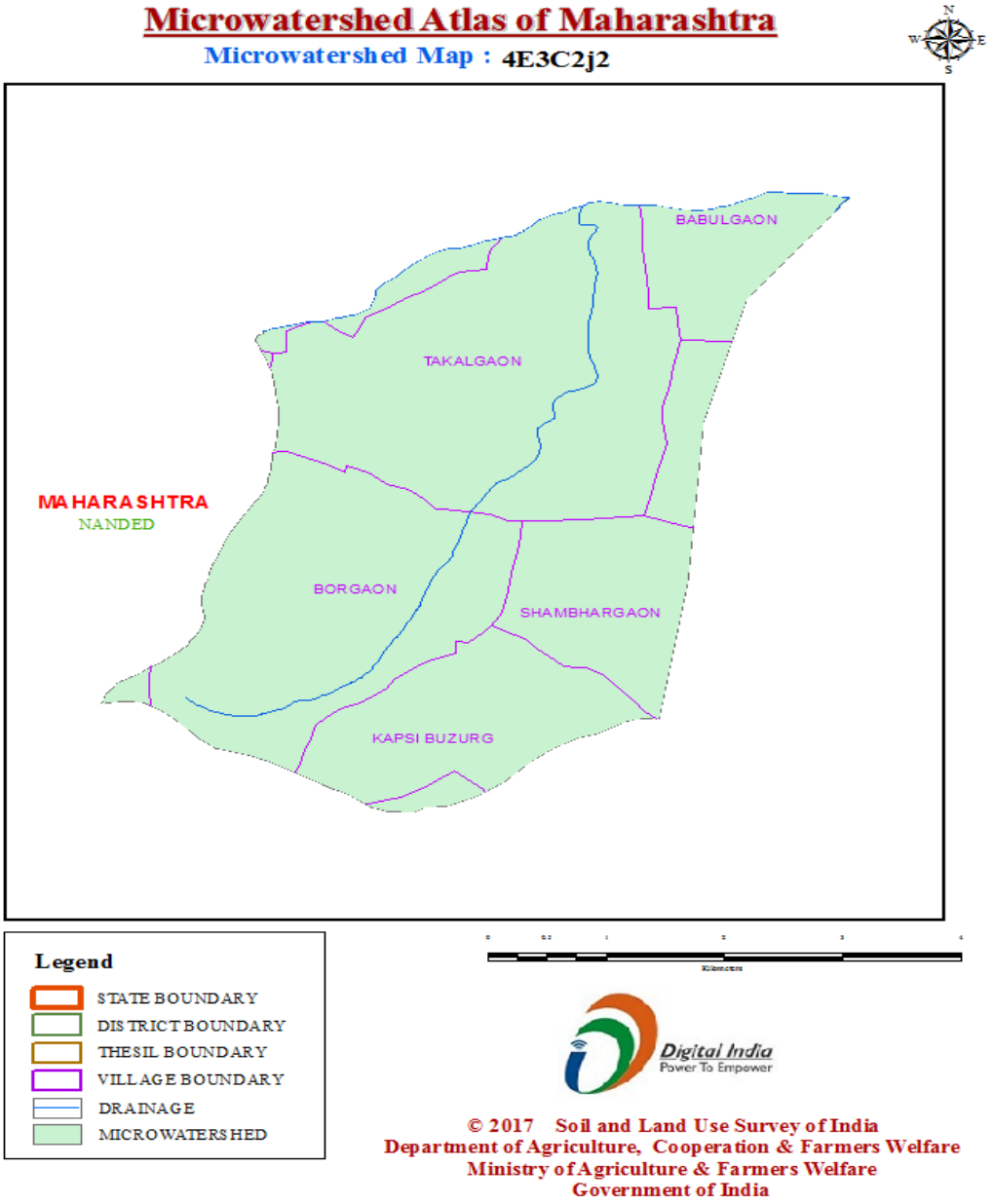
Name of Villages:- Patalganga and Sriganwadi Tauka Kandhar District Nanded.



Micro watershed number:-4E3C2j2

Total area:-1986.95 Sqm

Name of Villages:- Babulgaon, Shambhargaon, Takalgaon, Borgaon and kapshi Tauka Loha District Nanded.



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